Productive Struggle vs. Cognitive Overload: A Quantitative Analysis of Grade 7 Students' Performance on Complex Mathematical Tasks

Ryan C. Alarios., Mary O. Davales., Sarah C. Sabico., Delmier D. Jimenez., and Dr. Genesis G. Camarista

School of Education, Arts and Sciences, West Visayas State University - Himamaylan City Campus, Negros Occidental, 6108 Philippines

DOI: https://doi.org/10.51584/IJRIAS.2026.11100086

Received: 24 October 2026; Accepted: 29 October 2026; Published: 13 November 2026

ABSTRACT

This quantitative descriptive-correlational study examined whether Grade 7 students' engagement with complex MATATAG-aligned mathematical tasks reflected productive struggle or cognitive overload, and how these cognitive constructs relate to problem-solving performance. Using a purposive cluster sampling technique, data were collected from 272 Grade 7 students in a public secondary school. Participants completed a 20-item Productive Struggle Scale, a 20-item Multidimensional Cognitive Load Scale, and a 15-item criterion-referenced Problem-Solving Test. Descriptive results indicated high levels of perceived productive struggle and moderate cognitive load, yet students demonstrated extremely low problem-solving performance. Spearman rank-correlation analyses revealed no statistically significant relationship between productive struggle and performance, nor between cognitive load and performance. The quantitative findings challenge assumptions regarding the direct, positive transfer of effortful struggle into problem-solving performance in under-resourced contexts without explicit instructional heuristics. The study offers empirical implications for MATATAG curriculum implementation, task design, and Philippine mathematics instruction aligned with Sustainable Development Goal 4.

Keywords: productive struggle; cognitive load theory; mathematical problem solving; Grade 7 mathematics; MATATAG curriculum; quantitative research

INTRODUCTION

Background of the Study

Mathematics education in the twenty-first century has increasingly emphasized the development of higher-order thinking skills, conceptual understanding, and authentic problem-solving abilities rather than rote memorization and procedural fluency alone. Educational reforms across the globe advocate for the use of complex, non-routine mathematical tasks that challenge learners to reason, justify, analyze, and apply mathematical concepts in unfamiliar situations. According to the National Council of Teachers of Mathematics (NCTM, 2014), cognitively demanding tasks are essential in cultivating mathematical proficiency because they encourage learners to make sense of mathematical ideas and engage deeply in problem-solving.

Within this perspective, the concept of productive struggle has emerged as a critical component of meaningful mathematics learning. Productive struggle refers to students' effortful engagement with challenging mathematical tasks that eventually leads to conceptual understanding and learning gains (Warshauer, 2015). Rather than immediately providing solutions, teachers facilitate opportunities for learners to grapple with mathematical uncertainty, develop perseverance, and refine problem-solving strategies. Research suggests that productive struggle enhances conceptual retention, metacognition, and students' confidence in solving complex tasks (Kapur, 2008; Sztajn et al., 2018). Students who experience

appropriate levels of struggle are more likely to develop adaptive expertise and flexible mathematical thinking.

However, while challenge is necessary for learning, excessive difficulty may lead to cognitive overload. Cognitive Load Theory (CLT), originally proposed by Sweller (1988), explains that working memory has limited capacity. When mathematical tasks impose excessive intrinsic or extraneous demands, learners may experience frustration, confusion, and disengagement instead of meaningful learning. CLT distinguishes among intrinsic load, extraneous load, and germane load, emphasizing that instructional design should minimize unnecessary cognitive demands while supporting schema construction and meaningful learning (Sweller, Ayres, & Kalyuga, 2011).

This tension between productive struggle and cognitive overload is particularly relevant in mathematics classrooms where students engage in complex tasks requiring simultaneous processing of procedures, representations, symbols, and reasoning. In many instances, tasks intended to promote higher-order thinking may unintentionally overwhelm learners if they are poorly scaffolded or developmentally inappropriate. Consequently, understanding the balance between beneficial struggle and excessive cognitive load has become a significant concern in mathematics education research.

The issue is especially urgent in the Philippine educational context. Results from the Programme for International Student Assessment (PISA) 2022 revealed that Filipino learners continue to perform below the global average in mathematics, indicating persistent difficulties in problem-solving, reasoning, and application of mathematical concepts (OECD, 2023). In response, the Department of Education introduced the MATATAG Curriculum, which seeks to strengthen foundational skills and promote meaningful learning experiences through contextualized and cognitively engaging tasks (DepEd, 2023). Nevertheless, concerns remain regarding learners' readiness to engage in complex mathematical activities and teachers' capacity to design tasks that promote productive struggle without causing cognitive overload.

Although numerous studies have separately examined productive struggle and cognitive load, limited empirical research has quantitatively investigated how these constructs concurrently relate to mathematics achievement among Filipino Grade 7 learners. This gap highlights the need for a rigorous quantitative inquiry into the strength and direction of these relationships.

To address this gap, the present study was designed to quantitatively examine the levels of productive struggle, cognitive load, and problem-solving performance among Grade 7 students, as well as the relationships existing among these variables.

Statement of the Problem

This study aims to quantitatively investigate Grade 7 students' perceived productive struggle, cognitive load, and problem-solving performance when engaging with complex mathematical tasks.

Specifically, it seeks to answer the following research questions:

1. What is the level of students' perceived productive struggle and cognitive load when engaging with complex mathematical tasks?

2. What is the level of students' problem-solving performance after completing complex mathematical tasks?

3. Is there a significant relationship between students' perceived productive struggle and their problem-solving performance?

4. Is there a significant relationship between students' perceived cognitive load and their problem-solving performance?

LITERATURE REVIEW

Productive Struggle in Mathematics Learning

Productive struggle has become an important construct in mathematics education because it emphasizes the value of effortful engagement in developing conceptual understanding. According to Warshauer (2015), productive struggle occurs when students persist through challenging mathematical situations while receiving appropriate support from teachers. Rather than avoiding difficulty, learners are encouraged to wrestle with uncertainty, test strategies, and construct meaning independently. Similarly, Kapur's (2008) productive failure framework argues that initial struggle and unsuccessful attempts can prepare students for deeper understanding when formal instruction is later provided. Students who engage in productive struggle develop stronger conceptual connections, transfer knowledge more effectively, and demonstrate improved problem-solving abilities. Sztajn et al. (2018) further noted that effective teachers maintain high cognitive demand while strategically scaffolding students' learning processes.

Recent studies suggest that productive struggle promotes metacognitive awareness and resilience. When learners reflect on errors and revise their strategies, they become more self-regulated and adaptive in mathematical thinking (Hwang & Chang, 2021). However, productive struggle only becomes beneficial when tasks are appropriately designed and supported; otherwise, excessive frustration may occur (Zhang et al., 2023).

Cognitive Load Theory

Cognitive Load Theory (CLT) explains how limitations in working memory affect learning. Proposed by Sweller (1988), CLT posits that instructional materials should be designed to optimize cognitive processing and prevent overload. The theory identifies three types of cognitive load, as detailed in Table 1.

Table 1. Types of Cognitive Load

Type of Load	Definition
Intrinsic load	The inherent complexity of the learning task
Extraneous load	Unnecessary cognitive demands caused by poor instructional design
Germane load	Cognitive effort devoted to schema construction and learning

Note. Adapted from Sweller et al. (2011).

According to Sweller, Ayres, and Kalyuga (2011), excessive extraneous load interferes with learning because it consumes limited working memory resources. In mathematics education, cognitive overload may occur when students are simultaneously required to process symbols, diagrams, procedures, and unfamiliar contexts.

Van Merriënboer and Sweller (2010) emphasized that effective instructional design should reduce unnecessary cognitive burden while encouraging germane processing. Kirschner, Sweller, and Clark (2006) further argued that minimally guided instruction may overwhelm novice learners, particularly when tasks exceed students' prior knowledge and cognitive capacity.

Recent studies have explored adaptive instructional approaches that balance challenge and support. Researchers suggest that scaffolding, visual aids, chunking, and contextualized examples may help reduce extraneous cognitive load while preserving opportunities for meaningful problem solving (Lee & Kim, 2022).

Mathematical Problem Solving

Mathematical problem solving is widely recognized as a central goal of mathematics education. According to Pólya (1957), problem solving involves understanding the problem, devising a plan, carrying out the plan, and reflecting on the solution. Modern mathematics curricula emphasize not only procedural accuracy but also reasoning, communication, and strategic thinking.

Complex mathematical tasks require learners to apply concepts flexibly, connect representations, and justify solutions. Such tasks promote deeper learning because they require active cognitive engagement rather than memorization. Camarista (2016) underscored that engaging students in doing mathematics—creating, conjecturing, exploring, testing, and verifying—provides an avenue for meaningful instruction and fosters higher-order cognitive skills that allow learners to generalize concepts and rules. However, successful problem solving depends on several factors, including prior knowledge, metacognitive skills, motivation, and cognitive capacity.

Research indicates that effective mathematical problem solving requires strategic thinking, creativity, persistence, and the ability to analyze problems systematically (Nguyen et al., 2023). Their work highlighted the importance of developing flexible thinking strategies among learners to improve mathematical understanding and performance.

Research likewise suggests that affective and psychological variables significantly influence mathematical problem-solving outcomes. In a study conducted by Lee and Wang (2021), creativity and self-efficacy were found to positively relate to problem-solving performance among learners, whereas anxiety negatively affected performance. Similarly, Camarista (2015) demonstrated that self-efficacy beliefs and mathematical creativity play significant positive roles in determining problem-solving achievement, while math anxiety imposes a key psychological barrier to successful task execution. The literature underscores that students' confidence, emotional regulation, and creative thinking abilities contribute substantially to successful mathematical engagement and achievement. Salazar et al. (2022) further observed that while Filipino learners often exhibit high perseverance when working through challenging academic problems, persistent conceptual gaps frequently block performance success.

Philippine Context: PISA and the MATATAG Curriculum

The Philippine educational system continues to face challenges in mathematics achievement. Results from PISA 2022 showed that Filipino learners performed significantly below the OECD average in mathematics literacy, highlighting difficulties in reasoning, problem solving, and conceptual application (OECD, 2023).

In response, the Department of Education implemented the MATATAG Curriculum, which emphasizes foundational competencies, contextualized instruction, and higher-order thinking skills. The curriculum seeks to streamline content and provide learners with deeper opportunities for conceptual understanding and authentic problem solving (DepEd, 2023).

Despite these reforms, challenges remain in classroom implementation. Teachers often struggle to design cognitively demanding tasks that remain accessible to diverse learners. Additionally, many Filipino students experience difficulties in mathematical comprehension due to language barriers, limited resources, and gaps in foundational knowledge. These realities highlight the importance of quantitatively measuring how students experience complex mathematical tasks within the Philippine context.

Theoretical Framework

This study is anchored on the synthesis of two theoretical frameworks: the Productive Struggle Framework (Warshauer, 2015; Sztajn et al., 2018) and Cognitive Load Theory (Sweller, 1988; Sweller et al., 2011).

The Productive Struggle Framework posits that meaningful conceptual development requires effortful engagement (E) with non-routine tasks. Conversely, Cognitive Load Theory assumes working memory constraints (C) delimit processing capacity, where Total Load (L_T) is defined as:

$$L_T = L_{intrinsic} + L_{extraneous} + L_{germane}$$

Effective learning requires that $L_T \leq C$. When tasks lack structured scaffolding, $L_{extraneous}$ spikes, resulting in cognitive overload ($L_T > C$) which neutralizes the positive cognitive potential of productive struggle. This integrated framework hypothesizes that high self-reported struggle alone does not yield performance gains unless cognitive load is maintained within manageable parameters.

METHODOLOGY

Research Design

This study employed a quantitative descriptive-correlational research design. According to Siedlecki (2020), descriptive-correlational research systematically describes variables and evaluates the statistical relationships occurring between them without experimental manipulation. This design was selected to determine the levels of perceived productive struggle, cognitive load, and problem-solving performance among Grade 7 students, and to quantify the bivariate relationships between these cognitive constructs and academic performance.

Participants and Sampling

The target population comprised Grade 7 students in a public secondary school during the 2025–2026 academic year. A cluster sampling technique was utilized, where intact sections (clusters) were randomly selected. The initial sample consisted of 273 Grade 7 students. One student was absent during the data collection window, yielding a final sample of 272 participants.

Instruments

Data were collected using three quantitative instruments. Prior to the main administration, all three instruments were pilot-tested on a non-participant sample of Grade 7 students ($n = 50$) to evaluate item clarity, formatting, time allocation, psychometric reliability, and overall administrability.

Productive Struggle Survey

A 20-item instrument scored on a 5-point Likert scale ($1 =$ Strongly Disagree to $5 =$ Strongly Agree) was adapted from Warshauer et al. (2017) to measure student persistence, tension, and resilience during complex mathematical task engagement. The scale demonstrated strong content validity through expert review (Content Validity Ratio, $CVR = .85$) and robust internal consistency during pilot testing ($\alpha = .793$).

Multidimensional Cognitive Load Scale (MLCX)

A 20-item scale derived from Leppink et al. (2013) assessed intrinsic, extraneous, and germane cognitive load during task completion on a 5-point Likert scale ($1 =$ Very Low to $5 =$ Very High). The instrument demonstrated strong overall internal consistency during pilot testing ($\alpha = .766$). (CVR = ?)

Mathematics Performance Assessment

15-item criterion-referenced problem-solving test was developed in alignment with DepEd MATATAG Most Essential Learning Competencies (MELCs) and Stein et al.'s (2017) high-cognitive-demand framework. A Table of Specifications (TOS) was prepared prior to item construction to ensure the representativeness and balanced distribution of items across the mathematical topics covered. Items were scored using a 4-point rubric ($0 =$ No Response/Incorrect to $3 =$ Complete Solution with Justification), yielding a total possible

score range of 0--60. Pilot results confirmed appropriate item clarity and overall administrability, with high test reliability ($KR\text{-}20 = .82$).

Data Collection Procedures

Data collection was executed in a single day across three sequential 60-minute class sessions following institutional ethical approval (DepEd Order No. 32, s. 2023). To mitigate participant fatigue and preserve cognitive stamina, structured rest and non-academic transition intervals were provided between sessions. The administration sequence proceeded as follows:

Session 1 (Task Engagement): Participants engaged with two high-cognitive-demand mathematical tasks (45 minutes) under standard classroom conditions (individual work, bilingual English/Hiligaynon instructions).

Session 2 (Immediate Post-Task Measures): Following a short relaxation interval, students completed the Productive Struggle Survey (8 minutes) and the MLCX Cognitive Load Scale (7 minutes). Instrument administration order was counterbalanced ($n = 136$ struggle-first; $n = 136$ load-first) to control for order effects.

Session 3 (Performance Assessment): After an extended rest break, students completed the independent 15-item Mathematics Performance Assessment (40 minutes). Completed tests were blind-scored by two independent raters, yielding high inter-rater agreement (Intraclass Correlation Coefficient, ICC = .89).

Data Analysis

Data were analyzed using SPSS (Version 28). To address Research Questions 1 and 2, descriptive statistics—specifically means (M), standard deviations (SD), and formal scale intervals—were computed to summarize the levels of perceived productive struggle, cognitive load, and problem-solving performance. To address Research Questions 3 and 4, inferential statistics using Spearman's rank correlation coefficient (r_s) were performed at a significance level of $\alpha = .05$ (two-tailed). Spearman's rank correlation was selected as the appropriate non-parametric test because preliminary statistical evaluations revealed non-normal data distributions (evidenced by significant skewness/kurtosis values) and ordinal measurement characteristics within the self-report survey scales, thereby violating the normality and interval-data assumptions required for parametric Pearson correlation analysis. The magnitudes of the correlation coefficients were interpreted based on Cohen's (1988) criteria: $r < .10$ indicated a negligible relationship, $.10 \leq r \leq .29$ indicated a small relationship, $.30 \leq r \leq .49$ indicated a medium relationship, and $r \geq .50$ indicated a large relationship.

Ethical Considerations

This study adhered strictly to the ethical research standards set forth in Department of Education (DepEd) Order No. 32, s. 2023 (Research Ethics Protocol) and the principles of the Declaration of Helsinki. Prior to data gathering, formal institutional clearance and written permissions were granted by the Division Office and the school principal. Informed consent forms detailing the study's pure quantitative nature, purpose, volumetric time commitment, and non-academic impact were distributed to parents and legal guardians of all potential Grade 7 participants, yielding a 100% consent rate ($N = 272$). Assent was obtained directly from students through an age-appropriate written protocol explaining that participation was voluntary and that withdrawal could occur at any point without penalty or prejudice to their academic standing.

To preserve confidentiality and participant anonymity, no personal identifiers were recorded on the survey instruments or assessment sheets; all quantitative data were anonymized using alphanumeric identification codes ($S001\text{--}S272$). To address potential psychological stress or test anxiety stemming from challenging tasks, pre-task orientations normalized difficulty, and structured rest intervals were integrated into the administration protocol. All hardcopy instruments and raw digital data were stored on password-protected, encrypted drives accessible exclusively to the primary researchers. Per DepEd guidelines, physical records

will be securely shredded and digital files permanently erased five years after study completion.

RESULTS

Descriptive Levels of Productive Struggle, Cognitive Load, and Performance (RQ1–RQ2)

Table 1 presents the descriptive statistics for students' perceived productive struggle and cognitive load during complex mathematical task engagement.

Table 2. Level of Students' Perceived Productive Struggle and Cognitive Load During Complex Mathematical Tasks Engagement (N = 272)

Construct	**n**	**Mean**	**Description**	***SD***
Productive Struggle	272	3.97	High	.33
Cognitive Load	272	2.97	Moderate	.26

Note: *4.51-5.00 Very High; 3.51-4.50 High; 2.51-3.50 Moderate; 1.51-2.50 Low; 1.00-1.50 Very Low*

Grade 7 students reported high levels of perceived productive struggle ($M = 3.97, SD = .33$), demonstrating substantial self-perceived effort and persistence. Cognitive load was maintained at a moderate level ($M = 2.97, SD = .26$).

Table 2 presents students' overall problem-solving performance.

Table 3. Level of Students' Problem-Solving Performance When Engaging with Complex Mathematical Tasks (N = 272)

Variable	***n***	**Mean**	**Description**	***SD***
Problem-Solving Performance	272	5.85	Very Low	3.03

Note: *48.01-60.00 Very High; 36.01-48.00 High; 24.01-36.00 Average; 12.01-24.00 Low; 0.00-12.00 Very Low*

Despite reporting high productive struggle, students achieved a mean problem-solving score of $M = 5.85$ ($SD = 3.03$), representing an overall mastery rate of only 9.75%.

Relationships Between Variables (RQ3–RQ4)

Table 3 presents the association between perceived productive struggle and problem-solving performance.

Table 4. Correlation Between Students' Perceived Productive Struggle and their Problem-Solving Performance (N = 272)

Variable	**1**	**2**
Productive Struggle	-	-.06
Problem-Solving Performance	-.06	-

Note. r = Spearman's p correlation coefficient. No asterisks indicate $p > .05$.

Table 4 presents the association between perceived cognitive load and problem-solving performance.

Table 5. Correlation Between Perceived Cognitive Load and Problem-Solving Performance

Variable	1	2
Cognitive Load	-	.08
Problem-Solving Performance	.08	-

Note. $N = 272$. Values represent Spearman's p correlation coefficients.

Perceived productive struggle demonstrated a negligible and statistically non-significant correlation with performance ($r = -.06, p = .321$).

DISCUSSION

The Paradox of High Engagement and Low Performance

The primary finding of this study is the striking, paradoxical divergence between Grade 7 students' high self-reported productive struggle (M = 3.97, SD = .33), moderate cognitive load (M = 2.97, SD = .26), and extremely low problem-solving performance (M = 5.85/60, SD = 3.03; a 9.75% mastery level). Theoretically, productive struggle is conceptualized as an essential driver of conceptual understanding, as effortful wrestling with complex mathematical ideas allows learners to construct deeper schema rather than passively execute procedures (NCTM, 2014; Warshauer, 2015). Similarly, Cognitive Load Theory (CLT) posits that maintaining total cognitive load at a moderate, manageable level optimizes working memory for schema construction and germane processing (Sweller, 1988; Sweller et al., 2011). However, the present empirical findings directly challenge these conventional assumptions by demonstrating that high self-perceived effort and manageable cognitive demands do not automatically translate into successful problem-solving outcomes.

This discrepancy suggests that the struggle experienced by students was not genuinely productive, but rather represented *unproductive persistence*. While students exhibited strong behavioral and affective willingness to engage—reflecting the perseverance previously observed among Filipino learners by Salazar et al. (2022)—they lacked the underlying strategic competence, procedural fluency, and conceptual foundation necessary to resolve non-routine tasks. As Kapur (2016) emphasized, struggle yields learning gains only when students possess sufficient prior knowledge and cognitive prerequisites to reorganize and integrate novel mathematical concepts. In the absence of these foundational schemas, prolonged effort merely yields persistent confusion rather than conceptual growth.

This structural gap reflects broader systemic challenges within the Philippine basic education context. Filipino learners' performance in international large-scale assessments, such as the Programme for International Student Assessment (PISA) 2022, revealed persistent baseline deficits in mathematical literacy, reasoning, and application, with an average score of $M = 353$ compared to the global average (OECD, 2023). Many students enter Grade 7 with significant foundational gaps in lower-grade numeracy and proportional reasoning. Consequently, when introduced to cognitively demanding tasks aligned with the MATATAG Curriculum—which heavily emphasizes Higher-Order Thinking Skills (HOTS), contextualization, and non-routine problem solving (DepEd, 2023)—the sudden increase in task complexity severely strains students' mathematical capacity. Thus, the observed performance deficit is not merely a failure of immediate task effort, but rather the cumulative effect of prior learning gaps.

Productive Struggle and the Failure of Effort to Translate into Achievement

The negligible, non-significant correlation between perceived productive struggle and problem-solving performance ($r_s = -.06, p = .321$) directly contradicts prior empirical literature advocating the linear

benefits of struggle in mathematics instruction (Kapur, 2008; Warshauer, 2015; Zhang et al., 2023). In optimal learning environments, effortful engagement is positively associated with performance because it is bounded by timely instructional scaffolding and heuristic support. The absence of a relationship in this study indicates that subjective exertion alone is insufficient to induce problem-solving success.

Several theoretical mechanisms account for this non-significant relationship. First, regarding the *absence of heuristic strategies and strategic competence*, Camarista (2016) argued that successful problem solving requires far more than persistence; it demands flexible reasoning, systematic task analysis, and the deployment of specific mathematical heuristics (e.g., drawing representations, working backward, identifying patterns). Students who lack a repertoire of problem-solving heuristics continue to struggle mechanically without making tangible progress toward a solution.

Second, the *interplay of affective and metacognitive factors* plays a critical role. Effective productive struggle relies heavily on metacognitive monitoring—the ability to evaluate strategy effectiveness and pivot when stuck (Hwang & Chang, 2021). Without metacognitive regulation, students exert high effort on flawed approaches. Furthermore, Camarista (2015) demonstrated that mathematical problem-solving performance is constrained by affective constructs, where low self-efficacy and high math anxiety act as psychological barriers that neutralize the cognitive benefits of persistence.

Finally, *scaffolding deficits in resource-constrained environments* exacerbate these performance gaps. Warshauer (2015) emphasized that struggle remains productive only when teachers provide explicit, expert scaffolding at critical junctures (Kirschner et al., 2006). In under-resourced instructional settings, tasks intended to foster independent discovery may inadvertently leave novice learners stranded in unproductive struggle, maintaining high self-reported effort without achieving conceptual breakthroughs.

Cognitive Load Dynamics and Metacognitive Calibration

The weak, non-significant correlation between perceived cognitive load and problem-solving performance ($r_s = .08, p = .213$) provides a nuanced perspective on Cognitive Load Theory (Sweller et al., 2011). Standard interpretations of CLT assume that high cognitive load impairs performance, whereas moderate load optimizes processing. However, these quantitative results demonstrate that moderate self-reported cognitive load ($M = 2.97$) can coexist with floor-level performance scores ($M = 5.85/60$).

This cognitive load neutrality can be explained through the lens of germane load and metacognitive calibration:

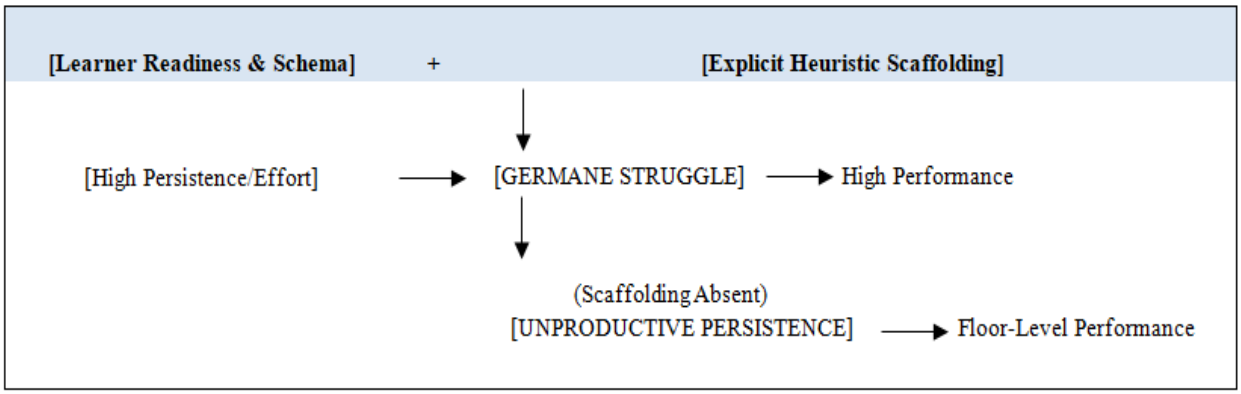
Absence of Germane Load Processing: According to van Merriënboer and Sweller (2010), total cognitive load comprises intrinsic, extraneous, and germane demands. A moderate self-reported score indicates that the tasks did not cause overwhelming subjective frustration or intrinsic overload. However, the absence of performance gains confirms that students were not engaging in *germane load processing*—the deliberate allocation of working memory capacity toward schema construction and abstraction.

Inaccurate Metacognitive Calibration: Novice learners frequently struggle to accurately gauge task difficulty and their own cognitive processing (Hwang & Chang, 2021). Grade 7 students may have miscalibrated their perceived mental load, interpreting basic reading or surface-level execution as moderate mental effort while remaining unaware of the complex mathematical structures they failed to process. Mediating Role of Prior Knowledge: Cognitive load is inherently dynamic and context-dependent. As Lee and Kim (2022) noted, the impact of cognitive load on performance depends heavily on prior schema. Two students experiencing identical task complexity will achieve vastly different performance outcomes depending on their foundational knowledge, self-efficacy, and task-specific confidence (Camarista, 2015).

Synthesis: Reconceptualizing the Productive Struggle–Cognitive Load Model

The combined quantitative findings require a conceptual revision of linear instructional models that directly connect student effort or cognitive load to achievement. Productive struggle and cognitive load do not act as

independent predictors of mathematical success. Instead, their impact is heavily moderated by learner readiness, foundational schema, metacognitive regulation, and instructional scaffolding.



As van Merriënboer and Sweller (2010) maintained, effective learning occurs at the intersection of task demand and student readiness. Exposing students to non-routine, MATATAG-aligned tasks without explicit heuristic training (Camarista, 2016) and structural scaffolding (Kirschner et al., 2006) converts intended productive struggle into unproductive effort. To fulfill the goals of Philippine mathematics reform and support sustainable educational development (SDG 4), instructional task design must pair cognitively demanding activities with structured, explicit scaffolding that enables learners to convert struggle into measurable mathematical achievement.

CONCLUSION AND RECOMMENDATIONS

To address why high self-reported engagement failed to translate into measurable problem-solving achievement, several underlying mechanisms were synthesized from the theoretical and empirical evidence:

Unproductive persistence versus genuine germane struggle. The disconnect between effort and performance probably stems from a breakdown in the learning process, wherein student effort reflected unproductive persistence rather than genuine productive struggle. Students presumably possessed the affective willingness and behavioral perseverance to remain engaged with challenging tasks; however, without crucial foundational schemas, their effort likely resulted in mechanical trial-and-error rather than meaningful conceptual processing (Kapur, 2016).

Absence of specific mathematical heuristics. The lack of correlation between struggle and performance is probably attributable to severe deficits in strategic competence among participants. As Camarista (2016) highlighted, persistence alone is insufficient to resolve complex tasks without systematic heuristic tools (e.g., drawing models, working backward, identifying underlying algebraic structures). Students perhaps expended considerable mental effort attempting to navigate non-routine tasks using rudimentary procedural approaches that were inherently unsuited for complex problem solving.

Inaccurate metacognitive calibration. The co-occurrence of moderate cognitive load and floor-level performance scores likely points to inaccurate metacognitive calibration among novice learners. Grade 7 students perhaps lacked the metacognitive monitoring necessary to evaluate task difficulty accurately (Hwang & Chang, 2021). Consequently, they presumably interpreted basic reading, surface-level execution, or initial task familiarity as "moderate mental effort," remaining unaware of the complex mathematical structures they failed to process.

Deficits in germane load processing. According to Cognitive Load Theory, total cognitive load must stimulate germane processing—the deliberate allocation of working memory capacity toward schema construction—for meaningful learning to occur (Sweller et al., 2011; van Merriënboer & Sweller, 2010). The results suggest that while tasks did not induce overwhelming subjective frustration (hence the moderate load scores), students presumably did not engage in germane schema building, probably because the gap between task difficulty and their prior knowledge was too wide to bridge independently.

Cumulative prior learning gaps in context. The floor-level achievement observed in this study is likely a reflection of broader, systemic foundational deficits accumulated prior to secondary education. As reflected in international metrics such as PISA 2022 (OECD, 2023), many Filipino learners enter Grade 7 with substantial gaps in baseline numeracy and proportional reasoning. When exposed to high-cognitive-demand tasks aligned with the MATATAG curriculum (DepEd, 2023), the sudden surge in task complexity presumably exceeded their developmental readiness, rendering effortful struggle unproductive in the absence of explicit, real-time teacher scaffolding (Kirschner et al., 2006; Warshauer, 2015).

RECOMMENDATIONS

Based on the empirical findings and synthesized conclusions of this study, actionable recommendations are provided for curriculum designers, educational administrators, classroom practitioners, and future researchers:

Curriculum design and policy alignment. The Department of Education (DepEd) and curriculum planners may explicitly pair high-cognitive-demand tasks within the MATATAG curriculum with structured, embedded scaffolding tools. Rather than assuming that exposure to complex tasks automatically triggers productive struggle, curriculum guides must incorporate concrete problem-solving heuristics—such as visual modeling, representation prompts, and structured metacognitive cues—directly into learning activity sheets. Bridging the gap between ambitious curricular goals (DepEd, 2023) and student readiness requires systematically scaffolding tasks to prevent effort from degrading into unproductive persistence.

Targeted diagnostic and remedial instruction. School administrators and mathematics department heads may consider instituting early-grade diagnostic assessments focusing on foundational numeracy and proportional reasoning at the onset of Grade 7. Given that cumulative learning gaps severely restrict students' ability to engage in germane load processing, targeted remediation modules must precede or run parallel to high-demand topics. Ensuring that baseline procedural fluency and conceptual schemas are established will enable learners to direct working memory capacity toward complex problem solving rather than rudimentary execution.

Instructional practice and worked-example integration. Mathematics teachers may need to adopt a gradual-release instructional framework when introducing non-routine problems. In light of Cognitive Load Theory principles (Sweller et al., 2011; van Merriënboer & Sweller, 2010), educators may balance open-ended tasks with explicit worked examples and partially completed solution templates ("completion problems"). Fading support as learners build competence reduces non-essential cognitive load, fosters accurate metacognitive calibration, and provides the strategic tools necessary for struggle to yield measurable achievement gains (Camarista, 2016; Kirschner et al., 2006).

Teacher professional development. Division- and school-level professional development programs may train mathematics educators to distinguish between *productive struggle* and *unproductive persistence* in real time. Workshops should equip teachers with adaptive questioning techniques and timely scaffolding strategies, enabling them to intervene before students succumb to task frustration or engage in mechanical, unstrategic effort.

Future quantitative research. Future empirical inquiries may employ experimental or longitudinal quantitative research designs to evaluate specific instructional interventions over time. Researchers are encouraged to test how targeted scaffolding strategies (e.g., worked-example fading, metacognitive strategy training) moderate the relationship between productive struggle, cognitive load, and problem-solving achievement across varied learner demographics and regional contexts.

REFERENCES

1. Camarista, G. G. (2015). Creativity, self-efficacy, anxiety, and problem-solving performance of the potential mathematically gifted. WVSU Research Journal, 4(2), 1–17.

2. Camarista, G. G. (2016). Problem solving, mathematical investigation and modelling. West Visayas State University.
3. Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Lawrence Erlbaum Associates.
4. Department of Education. (2023). MATATAG curriculum: Shaping the future of basic education (DepEd Order No. 010, s. 2023). Republic of the Philippines, Department of Education.
5. Hwang, G. J., & Chang, C. Y. (2021). Cognitive load management in mobile learning systems: Principles and theories. Computers & Education, 168, Article 104191. https://doi.org/10.1016/j.compedu.2021.104191
6. Hwang, G. J., & Chang, C. Y. (2021). Facilitating decision-making and problem-solving abilities in STEM education. Educational Technology Research and Development, 69(4), 2195–2200.
7. Kapur, M. (2008). Productive failure in mathematical problem solving. Instructional Science, 36(5), 379–400.
8. Kapur, M. (2016). Examining productive struggle in learning from performance in problem solving. Educational Psychology Review, 28(2), 289–306. https://doi.org/10.1007/s10648-015-9321-4
9. Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. Educational Psychologist, 41(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1
10. Lee, H., & Kim, Y. (2022). Balancing cognitive load and challenge in problem-solving instruction. Journal of Educational Psychology, 114(3), 512–528.
11. Lee, S., & Wang, C. (2021). Psychological antecedents of mathematical achievement: The roles of self-efficacy and anxiety. International Journal of STEM Education, 8(1), 1–14.
12. Leppink, J., Paas, F., Van der Vleuten, C. P., Van Gog, T., & Van Merriënboer, J. J. (2013). Development of a cognitive load scale for lecture-based instruction. Instructional Science, 41(5), 927–942.
13. National Council of Teachers of Mathematics. (2014). Principles to actions: Ensuring mathematical success for all. NCTM.
14. Nguyen, T., Zhang, L., & Liu, X. (2023). Cognitive strategies and metacognitive monitoring in complex problem solving. Educational Studies in Mathematics, 112(2), 245–263.
15. Organisation for Economic Co-operation and Development. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en
16. Pólya, G. (1957). How to solve it: A new aspect of mathematical method (2nd ed.). Princeton University Press.
17. Salazar, J., Ramos, M., & Mercado, C. (2022). Affective resilience and academic performance in Philippine secondary mathematics. Philippine Journal of Education, 99(2), 45–58.
18. Siedlecki, S. L. (2020). Understanding descriptive research designs. Clinical Nurse Specialist, 34(1), 8–12.
19. Stein, M. K., Smith, M. S., Henningsen, M. A., & Silver, E. A. (2017). Implementing standards-based mathematics instruction: A casebook for professional development (2nd ed.). Teachers College Press.
20. Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257–285.
21. Sweller, J., Ayres, P., & Kalyuga, S. (2011). Cognitive load theory. Springer Science & Business Media.
22. Sztajn, P., Confrey, J., Wilson, P. H., & Edgington, C. (2018). Learning trajectories in mathematics education. Mathematical Thinking and Learning, 20(1), 1–18.
23. van Merriënboer, J. J. G., & Sweller, J. (2010). Cognitive load theory in health professional education: Design principles and strategies. Medical Education, 44(1), 85–93. https://doi.org/10.1111/j.1365-2923.2009.03498.x
24. Warshauer, H. K. (2015). Strategies support productive struggle. Mathematics Teaching in the Middle School, 20(7), 390–393.

25. Warshauer, H. K. (2015). Productive struggle in middle school mathematics classrooms. Journal of Mathematics Teacher Education, 18(4), 375–400. https://doi.org/10.1007/s10857-014-9286-3
26. Warshauer, H. K., Starkey, C., & Herrera, C. (2017). Measuring productive struggle in middle school mathematics classrooms. Journal of Mathematical Behavior, 48, 112–128.
27. Zhang, Y., Chen, L., & Wang, K. (2023). Optimizing task difficulty for productive learning: An empirical evaluation. Contemporary Educational Psychology, 73, 102160.